Development of High-Performance Ammonia Borane Based Rocket Propellants

Completed Technology Project (2017 - 2021)

Project Introduction

Ammonia borane based fuels for use in hybrid rocket systems have the potential to be high performing while at the same time mitigating many of the issues associated with conventional liquid fuels (e.g. long term storage, toxicity, low density, etc). In addition, when used with a hypergolic oxidizer (e.g. white fuming nitric acid), the proposed fuels have the potential for use in systems requiring reliable restart capabilities. The goal of the proposed research is to investigate the behavior and performance of ammonia borane based propellants. While the primary focus of the proposed work would be related to ammonia borane as a potential fuel for hybrid systems, studies investigating its behavior as a fuel additive in solid propellants will be conducted as well. To characterize the burning rate behavior of the proposed hybrid propellants, regression rate analysis will be performed using a conventional opposed flow burner configuration as well as with a custom optically accessible hybrid rocket motor developed at Purdue University. Once the regression rate behavior has been adequately characterized, the information obtained will be used to develop hybrid fuel grains for testing with a conventional hybrid rocket motor. The restart capability diagnostic techniques like planar laser induced fluorescence as well as a novel temperature measurement technique based on phosphor therof the ammonia borane based fuels will be investigated by performing hypergolic ignition experiments on prepared fuel samples. If the ignition delays observed are short enough to prevent "hard starts", small scale hybrid motor tests will be performed with nitric acid based oxidizers. For some tests, the oxidizer flow rate will be intentionally interrupted followed by an attempted re-ignition of the motor. To date, there are very few publications in open literature related to the combustion behavior and flame structure of hybrid propellants. As a means of studying both the proposed fuels and hybrid propellants in general, laser mography (currently being developed at Purdue University) will be utilized. Obtaining a more fundamental understanding of these propellants could help inform future fuel formulations and fuel grain designs to further improve the performance of hybrid rocket systems. The In-Space Propulsion technology roadmap published by NASA (specifically TA 2.1.5.1) lists hybrid propulsion systems as a technology that could enhance a number of different proposed mission types as well as enabling a variety of explorer class missions. Predicted performance of the proposed ammonia borane based fuels meets the technology performance goals listed for hybrid propulsion systems while also having restart capability when used with typical hypergolic oxidizers. In addition, the stable solid state of ammonia borane makes it viable to store long term without the need for cryogenic cooling systems or storage tanks.

Anticipated Benefits

Ammonia borane based fuels for use in hybrid rocket systems have the potential to be high performing while at the same time mitigating many of the

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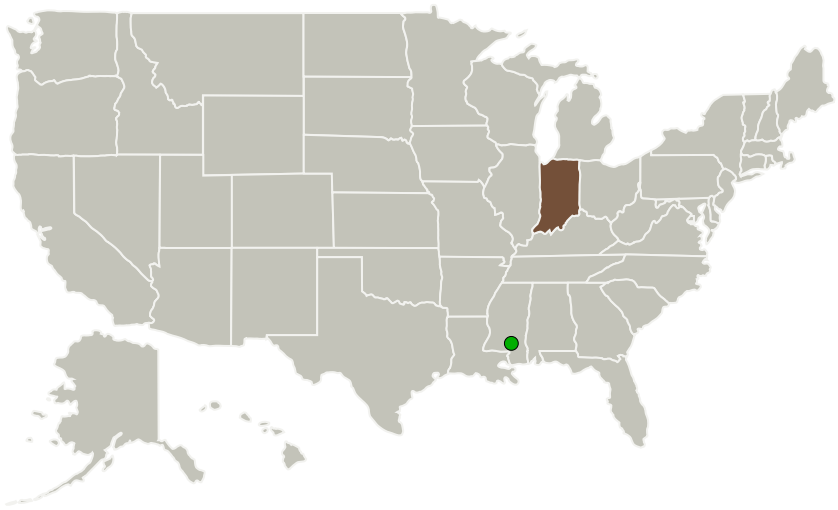
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Purdue University-Main Campus	Lead Organization	Academia	West Lafayette, Indiana
Stennis Space Center(SSC)	Supporting Organization	NASA Center	Stennis Space Center, Mississippi

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Purdue University-Main Campus

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Steven Son

Co-Investigator:

Michael J Baier

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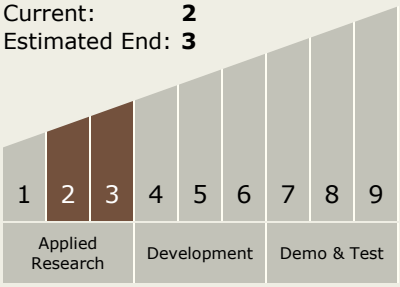
Primary U.S. Work Locations
Indiana

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.1 Chemical Space Propulsion
    - TX01.1.5 Hybrids

Target Destinations

Earth, The Moon, Mars